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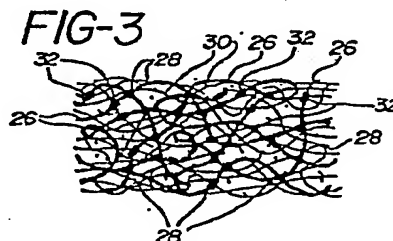
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(54) An entangled nonwoven fabric including bicomponent fibers and the method of making same.

(57) There is disclosed a thermal bonded entangled nonwoven fabric including conjugate fibers having an exposed low melting point component and a component having a higher melting point. The fabric may include only conjugate fibers or the conjugate fibers may be combined with other fibers. The fabric is formed by forming a web containing conjugate fibers, entangling the fibers of the web, heating the web to heat fuse the low melting point component of the conjugate fibers to fibers of the web at the fiber intersection.



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AN ENTANGLED NONWOVEN FABRIC INCLUDING BICOMPONENT
FIBERS AND THE METHOD OF MAKING SAME

5 TECHNICAL FIELD OF THE INVENTION

The invention relates to a thermal bonded, nonwoven fabric comprising entangled thermoplastic conjugate fibers alone, or in combination with base fibers, and to the method for
10 making said nonwoven fabric.

BACKGROUND OF THE INVENTION

Nonwoven fabrics have wide utility for use in both disposable and reusable applications, such as, e.g., aprons, towels, and wipes. There is continuing interest in producing such nonwoven fabrics having a combination of strength, and/or absorbency, and/or durability, and in manufacturing such fabrics by simple and efficient
15 methods.
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Highly entangled fiber fabrics has been long known in the art. Such fabrics rely primarily on interfiber frictional engagement for strength and integrity, and are expensive to produce. It is also known to utilize an extraneous binder with loosely entangled fibers, but this can lead to undesirable stiffness in the fabric, and the introduction of binder into the interfiber spaces reduces the absorbency of the fabrics. The problems associated with the formation of entangled fiber fabrics using certain synthetic fibers, such as, polyester, are particularly acute, since such fibers (due to their hydrophobic nature) are difficult to entangle, resulting in a loss of the number of frictional bonds, and subsequently, a weak fabric. A method and apparatus employed in forming an
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entangled nonwoven fabric of a variety of different fibers is disclosed in detail in Evans U.S. Patent No. 3,485,706.

5 Prior to Applicant's invention it has been known how to produce thermal bonded nonwoven fabrics from conjugate thermoplastic fibers by carding or air-laying a web consisting of a loose assemblage of conjugate fibers and thereafter passing the web through an oven, where at least one component of the conjugate fiber is melted and fused to adjacent fibers. Fabrics formed in this manner are described in detail in Davies U.S. Patent No. 3,511,747 and Davies et al. U.S. Patent No. 3,595,731. Conjugate fiber fabrics are also set forth in U.S.S.N. 383,260 and 10 382,731 filed June 2, 1982. Fabrics formed of bicomponent, or heterofil, fibers are typically more expensive than fabrics formed of single component, or homofil, fibers. Moreover, very high strength thermal bonded fabrics lack the softness or hand of entangled fabrics.

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20 Evans U.S. Patent No. 3,485,706 also discloses formation of an entangled fiber fabric formed of conjugate fibers. However, in accordance with the teachings of the Evans patent, such fabrics are comprised entirely of conjugate fibers, and the conjugate fibers are shrunk and relatively highly crimped, so as to give the resulting fabric elasticity. Fabrics formed of conjugate fibers in accordance with the Evans patent are retained in the entangled configuration solely by frictional engagement between the fibers, and there is no teaching or suggestion of melting any portion of the conjugate fibers to achieve a thermoplastic fusion or thermal bonding effect.

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One of the common problems associated with entangled fiber fabrics is fiber breakage, or linting, at the surface(s) of the fabric. This phenomenon, when aggravated, makes such fabrics unsuitable for use as a wound dressing, or

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the like, because the broken fibers may adhere to and accumulate in the wound. In order to provide entangled fiber fabrics with increased strength, and to reduce fiber breakage and linting, it has been known to treat entangled
5 fiber fabrics with a binder. However, many binders in common use today are objectional from a medical and surgical standpoint, and thus the problem remains.

10 The diaper facing material on the Moony diaper manufactured by Unicharm in Japan comprising a very lightly entangled blend of rayon and polyester fibers and about 5% conjugated fibers having a polypropylene core and polyethylene sheath. The fabric is very light weight, has little strength, and exhibits no fused entangled network
15 or superstructure.

It can be appreciated that an entangled fabric having the strength, resistance to wet collapse, and launderability imparted to the fabric by the combination of fusible
20 fibers and the like entanglement process would be a welcome addition to the art.

BRIEF SUMMARY OF THE INVENTION

25 The fabric of the invention is a nonwoven, thermally bonded entangled fabric comprising at least 10 percent conjugate fibers having an exposed surface component with a lower melting point than any other portion of the conjugate fibers. The fabric may also comprise other
30 fibers, including natural fibers, such as cotton, or synthetic fibers, such as rayon, polyester or other polyolefins.

The nonwoven fabrics of the invention are produced by a
35 process which comprises:

(a) providing a loose array of fibers comprising conjugate fibers having an exposed lower melting point component and possibly other fibers;

5 (b) entangling the fibers of the loose array using a process similar to that described in Evans U.S. Patent No. 3,485,706;

10 (c) subjecting said fibers to a temperature sufficient to melt the lower melting point component of said conjugate fibers while maintaining the fibers under minimal compression; and

15 (d) cooling said fibers to resolidify the lower melting point component of said conjugate fibers, to thereby bond said conjugate fibers to each other or possibly to other fibers at the fiber intersections, to create a fused, entangled network of fibers.

20 While it is encompassed within the present invention to make a fabric of solely entangled conjugate fibers, a nonwoven fabric formed in accordance with the instant invention will in its preferred embodiment be a generally homogeneous fabric comprising at least 10 percent
25 conjugate fibers interspersed throughout. The remainder of said fabric may comprise fibers of cotton, rayon, nylon or polyolefin fibers, such as polyester fibers, or other conventional fibers having sufficient length so they will not wash out during the entanglement process. The
30 conjugate fibers may be bicomponent fibers in which at least a portion of the outer surface has a lower melting temperature than the other component of the fiber.

35 The fabric derives strength by the entanglement process, which arranges the fibers and in particular the conjugate fibers in an entangled network. Further strength is

imparted by heating of the fibers to soften or melt the low melting point component of the conjugate fiber to create adhesion bonds with adjacent conjugate fibers or other fibers in the web. When heated the low melting point component of the conjugate fibers may flow to the fiber intersections and points of tangency of the fibers, and upon solidification, bridge and join adjacent fibers, forming inclusion bonds to supplement the interfiber frictional engagement resulting from the entanglement process. The high melting point components of the conjugate fibers retain their fiber integrity, and together with the fibers bonded thereto create a fused entangled fiber network which imparts added strength to the fabric, yielding a launderable fabric with enhanced resistance to wet collapse.

Thus, a fabric made in accordance with the present invention results in a strong fabric which is less expensive to produce and exhibits better abrasion resistance than solely entangled fabrics. Due to the strength imparted to the fabric by the entangling of the fibers, the fabrics exhibit better softness and hand than thermal bonded fabrics with comparable strength. In addition, the fabrics of the present invention do not require the addition of an adhesive binder which can reduce absorbency as well as desirability for medical and surgical use. By using a bicomponent fiber which retains its integrity during the fabric forming process, the fabric is strengthened and shows increased resistance to wet collapse, in addition to its other attributes. Though the fabrics formed in accordance with the present invention require no additive binder, they possess surface characteristics wherein little fiber breakage and linting takes place, making such fabrics suitable for medical and surgical use, such as for wound dressings. Such fabrics also have improved wash durability.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic side elevation of an apparatus suitable for carrying out the method of the invention;

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Figure 2 is an enlarged illustration of an entangled fabric incorporating conjugate fibers; and

Figure 3 is a view taken along line 3-3 of Figure 2.

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DETAILED DESCRIPTION OF THE INVENTION

The fabric of the present invention comprises at least 10 percent conjugate fibers. As used in this application, the term conjugate fibers includes thermoplastic fibers having at least two components of differing melting points. The fabric is entangled to provide interfiber frictional bonds and then heated to provide adhesion and/or inclusion bonding at plural fiber intersections.

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By fiber intersections, the present application intends to include not only points where fibers criss-cross one another, but also points of fiber tangency.

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Other fibers which may be included in the fabrics of the present invention include cotton, nylon, rayon and polyolefins. These fibers are normally from about 1/4 inch to 2 inches or longer in length, but this is intended to be exemplary only, since other fiber lengths can be employed so long as the fibers do not wash out during the entanglement process. During the heating process, the low melting point component of the conjugate fiber may melt and flow about said other fibers, creating inclusion bonds.

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In a preferred embodiment, the nonwoven fabric of the invention is made from a homogeneous blend of polyester fibers and polyester/polyethylene conjugate fibers.

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The various conjugate fibers that may be used include bicomponent fibers wherein the fiber components are arranged in side-by-side relationship. However, it is preferred to employ sheath/core bicomponent fibers, and even more preferred to employ sheath/core bicomponent fibers with polyethylene as the sheath and the polyester as the core. Either eccentric or concentric sheath/core fibers can be employed. The fibers will usually have a denier within the range of from about 1 to about 6, and are in excess of about 1/4 inch in length, up to about 3 or 4 inches long.

Preferably, the conjugate fibers employ high density polyethylene, that is, linear polyethylene that has a density of at least about 0.94, and a Melt Index ("M.I.") by ASTM D-1238(E) (190°C, 2160 gms.) of greater than 1, preferably greater than about 10, and more, most preferably from about 20 to about 50. Usually, the fibers will be composed of about 40 to 60 weight percent, and preferably 45 to 55 weight percent, polyester, the remainder being polyethylene. The polyester fiber, which makes up a large percentage of the fabric to be formed in accordance with a preferred embodiment of the invention, has a melting temperature above that of the polyethylene sheath so that the polyester is not melted during the thermal bonding step.

Other conjugate fibers having utility in the present invention are heterofil medium tenacity fibers. Such fibers, which are available from ICI Fibers, Harrogate, North Yorkshire, England, under product codes 3.3/100/V303, 3.3/50/V303, 6.7/50/V302, 13/65/V302, and 13/100/V302 include sheath/core fibers wherein the sheath is a nylon 6 material and the core is a higher melting point nylon 66 material. Such fibers are particularly useful in combination with polyester base fibers, and

illustratively, the layer of heterofil fibers will comprise at least about 10 percent by weight of the overall weight of the entangled fabric. Other medium tenacity heterofil fibers available from ICI Fibers for use in the present invention will include polyester fibers sold under product codes 3.3/50/V544 and 3.3/90/V544. Other suitable sheath/core fibers include fibers having polyethylene or polyethylene terephthalate as a core material and an isophthalic copolymer as the sheath material.

Other examples of polymer pairs suitable for use in the conjugate fibers of the fabrics of the present invention are copolyester/polyester, nylon/polypropylene, polypropylene/polyester, and nylon 6/polypropylene. The conjugate fibers made from these polymer pairs may comprise side-by-side or sheath/core polymer configurations.

The fabrics of the invention are produced by first forming a fibrous web comprising a loose array of fibers and conjugate fibers, as by carding, air-laying, or the like. It is preferred to employ a card, or a dual rotor such as is shown by Ruffo et al in U.S. Patent No. 3,768,118, as the web forming device, although other web forming apparatus can be employed if desired. The exact weight of the fibrous web has not been found to be narrowly critical. In a preferred embodiment the major portion of the homogeneous fabric made in accordance with the present invention is made up of the relatively less expensive polyester fiber and the balance is conjugate fiber. The percent by weight of the conjugate fibers may be as low as from about 10 percent to about 20 percent; however, if additional increased strength is desired the percentage of the relatively more expensive conjugate fibers can be increased up to about 100 percent by weight. The mechanism disclosed in the Ruffo et al patent is an air-laying apparatus which receives fibers from cards and is

capable of producing a web which can be made up of 100 percent conjugate fibers or a blend of conjugate fibers and other fibers in whatever proportion desired. The conjugate fibers may be concentrated at one or both of the major surfaces of the fabric in accordance with the teachings of the Ruffo et al patent.

Figure 1 shows one arrangement of apparatus that can be used to produce the fabrics of the invention. A homogeneous web 8 of loose conjugate and other fibers is produced by, e.g., a dual rotor. This composite web 8, comprising a loose array of conjugate fibers, e.g., polyester/polyethylene bicomponent fibers and other fibers, e.g., polyester fibers is supported on a liquid pervious support member such as an endless woven belt 10, which carries the web through an entangling mechanism 12 where a series of high pressure, fine, essentially columnar jets of water 14 impact the web, entangling the fibers. The high pressure water is supplied from manifold 16. The jets are arranged in rows disposed transversely across the path of travel of the belt 10. Preferably, there is a vacuum means 18 pulling a vacuum, e.g., of up to 5 to 10 inches of mercury, beneath the belt 10.

Evans, in U.S. Patent No. 3,485,706, describes a process and apparatus for rearranging/entangling fibrous webs by carrying such webs on a woven belt under a series of high pressure, fine, columnar jets of liquid. Apparatus of the general type disclosed by Evans can be used in the process of this invention, although typically the degree of entanglement contemplated by this invention is much less than that generally preferred by Evans.

*First entangling
device seen*

*liquid
gummed
or sticky*

The entangled fiber web is then conveyed by suitable mechanisms including belts 20, 22 to a heating means such as a forced air oven 24. In the oven 24, the web is subjected to an elevated temperature to melt at least part of the low melting point component (e.g., polyethylene) of the conjugate fibers, which will form adhesion and inclusion bonds at points of fiber-to-fiber contact, and/or at points of adjacent fiber tangency upon cooling and resolidification. As previously mentioned, the temperature in the heating zone is sufficiently high to melt at least part of the low melting component of the conjugate fibers, but insufficient to melt the higher melting point component (e.g., polyester) of the conjugate fibers, thus maintaining the fibrous form of the conjugate fibers in the fabric. The temperature is also insufficient to melt the base fibers which constitute the major portion of the web.

The web is preferably thermal bonded under conditions of zero pressure, or very light pressure, so that the web is not significantly crushed or compacted during the thermal bonding step. The exact temperatures employed in the thermal bonding step will vary, depending upon the weight and bulk density of the web, and upon the dwell time employed in the heated zone. For instance, bonding temperatures within the range from about 130° to about 180°C, have been found satisfactory for entangled webs comprised of a blend of polyester fibers and polyethylene/polyester sheath/core conjugate fibers of the type described above. Dwell times in the bonding zone will usually vary from about 2 seconds to about 1 minute, and more normally will be from about 3 to about 10 seconds. The important factor in selecting the heating conditions for optimum bonding is to heat the low melting point component to at least its melting point, but not to such a temperature that the higher melting point component of the

other fibers could melt. Thus, very high temperatures can be used with short exposure times, in order to achieve high speed operation.

5 In the thermal bonding step, the low melting point component of the conjugate fiber may be caused to flow to fiber intersections and to points of fiber tangency or adjacency, to entrap other fibers in a thermoplastic mass to form inclusion bonds. The low melting point component
10 also adheres to like material on the remaining conjugate fibers and to the other fibers in the web to bond such fibers to one another. Upon cooling, the welds of the fused low melting point component, e.g., polyethylene, solidify and excellent fiber-to-fiber bonds are thereby
15 formed. Simple exposure to ambient air will ordinarily provide adequate cooling. When polyester fibers are utilized as the other fibers, and polyethylene/polyester bicomponent fibers are utilized as the conjugate fibers, and the blended web is subjected to heating conditions
20 which substantially completely melt the polyethylene component of the conjugate fibers while leaving the polyester component thereof intact, the resulting entangled fiber fabric consists substantially completely of polyester fibers and remaining polyester cores that are retained in
25 the entangled configuration by the cooperative action of interfiber frictional engagement and thermal polyethylene bonds.

The Thermal bonding step can be carried out by through-air
30 bonding, as illustrated in Figure 1 by the oven, or by other means such as infrared heating or other types of radiant heating. Through-air bonding is accomplished by carrying the web on a porous conveyor belt through a zone where hot air is forced through the web. It can be
35 carried through a heated zone between two porous screens or belts, or it can be carried around a rotating drum

having a porous surface which is equipped to suck hot air through the web as it is passing around the drum. The exact method of effecting the heating has not been found to be narrowly critical. If desired, the thermal bonding step can be performed by passing the web between heated restraining belts, which apply moderate pressure, or between heated embossing or calendering rolls, which apply heavier pressure. With these latter methods, some compaction and densification of the web takes place. However, the application of pressure increases the number of fiber contact points and thermal bonds.

After thermal bonding and cooling to solidify the bonds, the fabric of the invention is collected, as on a conventional wind-up mechanism 25.

Referring now to Figures 2 and 3, there is illustrated in magnified form the construction of one nonwoven fabric made in accordance with the instant invention. As previously mentioned, the entangling mechanism acts to reform the loose array of fibers in the web 8 into an entangled fiber network.

Strong frictional bonds between the fibers will be obtained due to entanglement and strong thermal bonds are obtained where the conjugate fibers 26 are thermally joined to one another or to the other fibers in the web by adhesion bonds 28, and joined to other fibers 30 in the web by inclusion bonds 32. As shown at 32, inclusion bonds are formed as the low melting point component after conjugate fiber 26 meets and flows around the other fibers of the web. As shown at 34, the high melting point component of the conjugate fibers remain intact after thermal bonding. Since the fabric obtains strength from a combination of entanglement and thermobonding, it has better combination of strength and softness or hand than a

5 fabric formed by thermobonding alone, yet possesses the strength, abrasion resistance and resistance to wet collapse of a fabric made by thermal bonding. In addition, the adhesion bonds, inclusion bonds, and even areas of migration and accumulation of the low melting point component of the conjugate fibers provide increased resistance to fabric pull out or disentangling, displayed in increased fabric strengths and low surface linting of the fibers.

10

As shown in Figure 3, the entangling process results in a z-direction movement of the fibers, and generally creates a large number of intersections where the conjugate and other fibers are in contact. When the entangled web is heated, the low melting point component of the conjugate fibers 26 form adhesion bonds 28, and possibly inclusion thermal bonds 32 at the intersection and points of tangency of the conjugate fibers with other conjugate fibers and with the base fibers. This thermal bonding creates a fused entangled fiber network which greatly increases the strength of the fabric, and gives improved abrasion resistance and resistance to wet collapse.

25 The increased strength of the fabrics of the present invention attributable to thermal bonding may be seen in the following example. Carded webs of 20% CHISSO ES fibers having a polypropylene core and polyethylene sheath, and 80% polypropylene fibers were entangled, dried, and thermal bonded on steam cans at 310F. Sample 14628-1 was dried but not thermal bonded. Sample 146280-2 was dried and thermal bonded on-line by passing the web about a stack of steam cans. Sample 146280-3 was dried and thermal bonded by passing the web, disposed between two beets, about a stack of steam cans. A comparison of fabric properties is set out below.

35

<u>Property</u>	14628-1	146280-2	146280-3
	dry only	dry and bond, on-line	dry and bond, belt bonder
5 Grain Weight (gr/yd ²)	448.2	523.8	464.4
Grab Tensile Strength-MD (lb.)	2.87	14.20	8.01
Grab Tensile Strength-CD (lb.)	0.55	1.92	1.28
Grab Tensile Strength-MD/CD	5.20	7.40	6.26
10 Average Grab Tensile Strength (lb.)	1.71	8.06	4.65

Shrinkage, relative to Sample 146280-1, %	-----	16.9	3.6
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The increased strength in terms of both launderability and abrasion resistance, and the resistance to wet collapse of the fabrics according to this invention are achieved without the sacrifice to absorbency shown by fabrics combining loosely entangled fibers and, e.g., latex binder which fills the interfiber spaces. When binder material fills the interfiber spaces, it decreases absorbent capacity and disrupts the capillary network of the fabric. The following example illustrates the enhanced absorbent characteristics of the fabrics of the present invention as compared with loosely entangled fabrics with latex binder. Samples A, B, and C were made with 1 1/8 inch length, 1.5 denier AVTEX SN 1913 rayon and 1.5 inch length, 3.0 denier BICO 1050 polyethylene/polyester sheath/core conjugate fibers made by American Enka. 2.0 oz./yd.² webs were entangled on a 5710 Duotex belt made by Appleton Wire. The web and belt were passed under columnar jets of water from a strip of orifice of 0.007 inch diameter, disposed at 30/inch. The samples underwent 2 passes under the strips at 100 psi water pressure, 3 passes at 300 psi, 3 passes at 500 psi and then 10 passes at 1000 psi. The

samples were then thermobonded in an oven at 300°F for 20 seconds under no pressure. Sample D was made from a 2.0 oz./yd.² web of 1 1/8 inch, 1.5 denier AVTEX SN 1913 rayon. The web was entangled on the same belt and with the same orifice strips as samples A, B, and C, but with 3 passes at 100 psi, 3 passes at 150 psi, and 24 passes at 600 psi. The web was then saturation bonded with an acrylic binder solution and dried, to produce a ratio of 872 gms of fiber to 55 gms of binder in the final fabric. The samples were tested for absorbent capacity using an SAC test, take-up rate using an ATS test, and residue (or substrate surface dry ability) and launderability using the test methods described below.

The Gravimetric Absorbency Tester (GAT) described in U.S. 4,357,827 which was issued November 9, 1982, and which is incorporated herein by reference, is used to determine the Saturated Absorbency Capacity (SAC) and the Apparent Take-up Speed (ATS).

The GAT is set for a positive hydrostatic head by raising the base plate 3mm above the zero hydrostatic head position. A sample is die cut to 10 cm. in diameter, weighed on an analytical balance to the nearest 0.001 gram, and is affixed to the sample holder of the GAT. The sample holder is placed on the point source base plate and a 100 gram weight is imposed on top of the sample holder. This weight plus the weight of the sample holder provides a pressure of 0.05 psi on the test specimen. The chart speed is set at 3 cm/min. The balance is tared. The test is started and allowed to proceed until the balance read-out stabilizes. The maximum weight achieved which represents the maximum amount of fluid absorbed by the test specimen is recorded.

The SAC is determined by dividing the maximum amount of fluid absorbed by the specimen (balance readout) by the dry weight of the test specimen. The results are expressed as grams of fluid absorbed per gram of fabric.

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The 25% saturation point is determined by multiplying the balance readout by .25 and the 75% saturation point by multiplying by .75. On the GAT chart the 25% and 75% saturation points are connected by a straight line. The slope of this line is designated by the ATS with the results expressed as grams of fluid absorbed per gram of test specimen per sec. and is a measurement of the take up rate or rate at which the test specimen takes up fluid.

15 Accelerated wash tests are done using a Launder-O-Meter unit supplied by Atlas Electric Devices Co. of Chicago, Ill. Test specimens are laundered under specified conditions of temperature, liquid level, soap concentration and abrasive action so that launderability is evaluated in a conveniently short time.

20 The Launder-O-Meter is set for a bath temperature of 160°F and run until a stabilized temperature is reached. The specimen to be tested is cut to a size of 2 inches by 6 inches and placed in a container along with a standard AATCC 9.2% soap solution obtained by AATCC Research Triangle Park, North Carolina and fifty 1/4" diameter steel balls. The container is placed in the basket of the Launder-O-Meter and positioned in the preheater/storage unit until the temperature reaches 120°F. After preheating, the basket is placed on the rotor of the Launder-O-Meter, the unit started, and the time cycle set for 60 minutes. At the completion of the cycle the specimen is removed and inspected. Failure of the specimen is noted by visual inspection for any holes. If the specimen passes, it is recycled by the above procedure. This process continues

until the specimen fails or until the test is terminated. The wash durability test results are reported as the number of hours of successful wash or the number of hours to wash failure.

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- The residue test measures wicking efficiency and yields an indication of the ability of the test specimen to wipe surfaces dry. To perform this test, a glass plate is placed on an analytical balance and the balance tared.
- 10 From the previously conducted SAC the 50% SAC level is calculated and this amount of liquid is carefully dispensed onto the glass plate so as to cause it to puddle in the center of the plate. A test specimen is die cut in a 10 c.m. diameter and carefully placed on the plate over
- 15 the puddle of liquid. Twenty seconds are allowed for the specimen to reach an equilibrium absorption after which the test specimen is removed from the glass plate and the weight of the liquid which remains on the plate is read directly from the balance. This weight of liquid is the
- 20 residue and is reported in grams of liquid.

SAMPLE	SAC G/G	ATS G/G PER SEC.	RESIDUE G.	TENSILE	STRENGTH	LAUNDEROMETER
				MD	CD	EVALUATION TIMES TO FAILURES
A						
33% BICO 1050	9.53	0.249	0.038	7.48	5.63	2 hours
67% RAYON						
B						
20% BICO 1050	9.25	0.226	0.031	6.63	5.13	1 hour
80% RAYON						
C						
10% BICO 1050	8.61	0.194	0.021	6.94	5.87	1 hour
90% RAYON						
D						
100% RAYON, BINDER	6.96	0.147	0.024	10.5	4.60	2 hours

NOTE: ABSORBENT CAPACITY, ABSORBENT RATE, AND RESIDUE WERE EVALUATED UNDER 0.05 PSI PRESSURE.

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The fabrics of the present invention exhibited greater absorbent capacity and take-up rate than sample D. The fabrics of the present invention also showed increasing absorbent capacity and take-up as the percentage of ENKA
5 conjugate fibers were increased from 10 percent to 20 percent to 33 percent. The fabrics of the present invention exhibited good surface drying ability, though the surface drying ability declined with increasing percentage of the non-absorbent conjugate fibers or
10 decrease in percentage rayon. Surface drying ability may be improved by treating the fabric with a surfactant. Samples A and D showed comparable durability.

Samples of the diaper facing material on the Unicharm
15 Moony diaper were also subjected to the Launder-O-Meter test described above, however the time cycle was set for 20 minutes. Upon inspection after 20 minutes the fabric sample was substantially disintegrated.

20 The fabrics of the present invention may be entangled on a variety of supporting belts to achieve a broad range of fiber structures and fabric appearances, as is known in the art. For instance, the fabrics may appear apertured or unapertured and may have localized tufts or nubs of
25 entangling, or elongated ribs of entangled fibers extending across the fabric.

The foregoing description and drawings are illustrative but are not to be taken as limiting. Other variations and
30 modifications are possible without departing from the spirit and scope of the present invention.

CLAIMS:

1. A entangled nonwoven fabric comprising at least
10 percent conjugate fibers, said fabric having a
5 combination of both strength wash durability absorbency
and resistance to wet collapse, said fabric comprising an
entangled, fused network of conjugate fibers comprising an
exposed low melting point component, and a higher melting
point component, said conjugate fibers having been heated
10 to a temperature to melt said low melting point
components, whereby said conjugate fibers are thermal
bonded to yield a fabric with increased strength,
resistance to wet collapse and launderability.
- 15 2. A fabric as in Claim 1, comprising conjugate fibers
and other fibers, wherein said conjugate fibers are
thermal bonded to the other fibers of the web.
3. A fabric as in Claim 1 or 2, wherein said low melting
20 point component of said conjugate fibers form inclusion
bonds with said other fibers at the intersections of said
conjugate fibers and other fibers.
4. A fabric as set forth in Claim 3 in which the
25 conjugate fibers comprise a core component and a sheath
component, in which the sheath component is a low melting
point component.
5. A fabric as set forth in Claim 3 in which the
30 components of the conjugate fibers are disposed in side-
by-side relationship.
6. A fabric as set forth in Claims 2, 3, 4, or 5 in which
the lower melting point component is polyethylene.

7. A fabric as set forth in Claim 6 comprising a polyester component.

5 8. A fabric as set forth in Claim 1 in which the fabric is comprised of a homogeneous blend of said conjugate fibers and other fibers.

9. A fabric as set forth in Claim 1 or 2 comprising at least 20 percent conjugate fibers.

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10. A fabric as set forth in Claim 1 or 2 comprising at least 33 percent conjugate fibers.

15 11. A fabric as set forth in Claim 1 in which the other fibers are polyolefins.

12. A fabric as set forth in Claim 10 in which the other fiber is polyester.

20 13. A fabric as set forth in Claim 1 in which the other fibers are cotton.

14. A fabric as set forth in Claim 1 in which the other fibers are rayon.

25

15. A method of forming a nonwoven fabric comprising the steps of: providing a web comprising conjugate fibers having an exposed low melting point component and a higher melting point component: passing essentially columnar jets of fluid under pressure through said web to entangle said fibers; and heating said web to thermal bond said low melting point components of said conjugate fibers at fiber intersections to increase the strength of the fabric.

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16. A method as in Claim 15 wherein said web comprises conjugate fibers and other fibers, and said conjugate fibers are thermal bonded to the other fibers of the web at fiber intersections.

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17. A method as in Claim 15 or 16 wherein said low melting point component of said conjugate fibers is caused to flow, to form inclusion bonds with said other fibers at the intersections of said conjugate fibers and other fibers.

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18. A method as set forth in Claim 15 in which the conjugate fibers and other fibers are blended into a homogeneous web.

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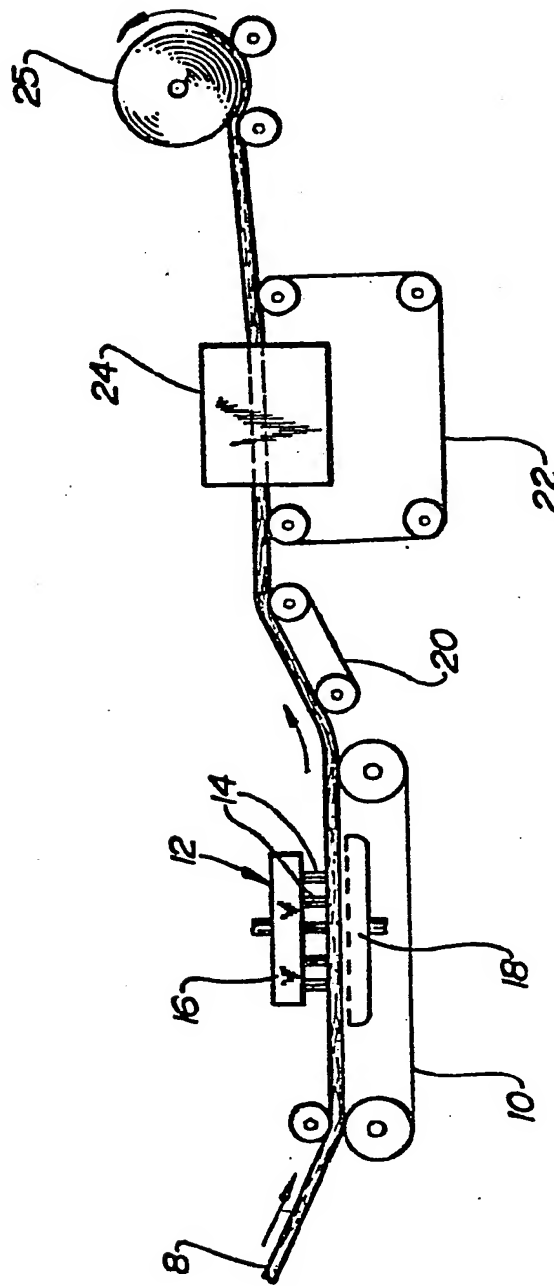
19. A method as set forth in Claim 15 in which said heating step is performed by subjecting said web to hot air.

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20. A method as set forth in Claim 15 in which said heating step is performed by subjecting said web to radiant heating.

1/2

FIG-1



2/2

FIG-2

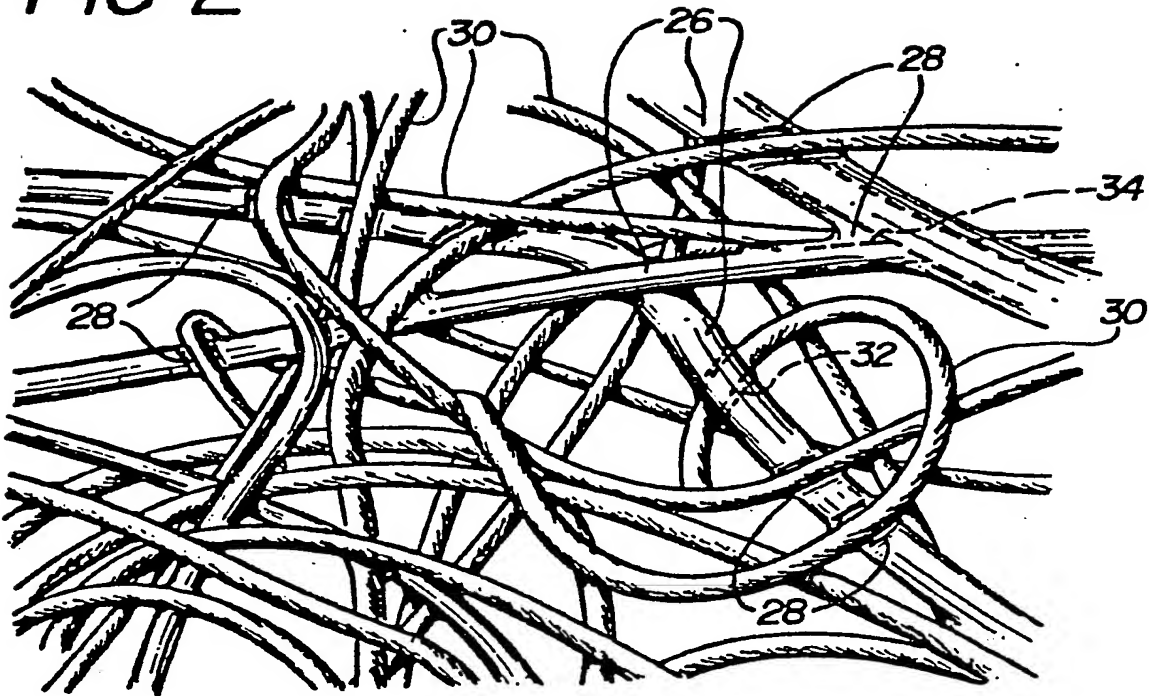
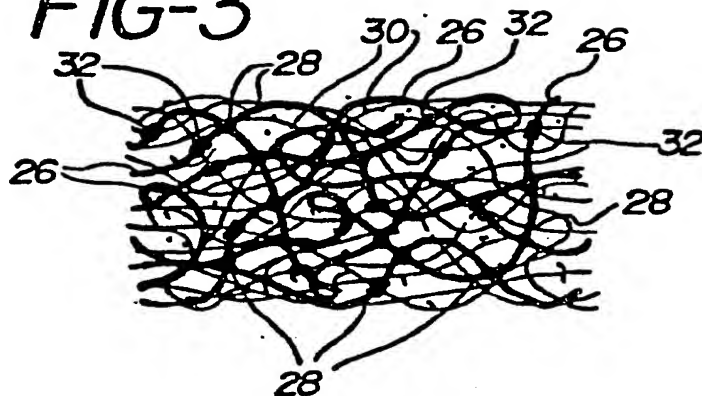


FIG-3



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